

# Update on Fracking in Kentucky

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Kentucky Geological Survey



Kentucky Environmental Quality Commission  
Louisville, Kentucky, 5-Jun-2014



A large hydraulic fracturing (fracking) rig is shown in operation in a wooded area. The rig consists of a tall, vertical metal structure with a flag on top. A yellow excavator is positioned next to the rig, and a white pickup truck is parked nearby. The background is filled with green trees and foliage.

# What is fracking?



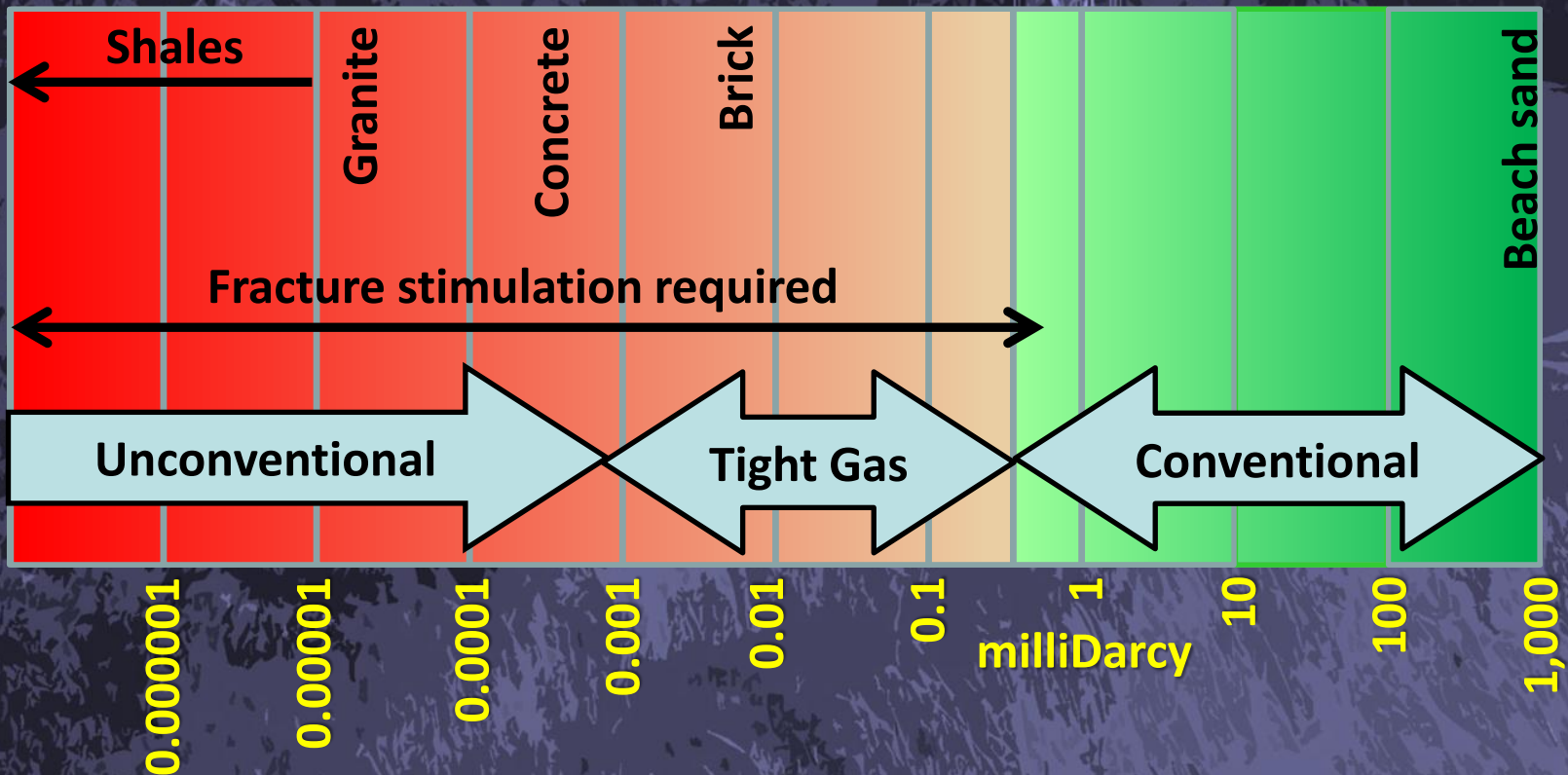
# Fracture Stimulation

- Inject high-pressure fluids underground
- Break the rock
- Connect to existing natural fractures
- Create more surface area (contact more rock)
- Create pathways for oil and gas to flow into the well bore



# Why Frac?

Permeability: ease of fluid flow





# There are many methods for fracking a well.

- Explosives

- Black powder
- Nitroglycerine
- ANFO

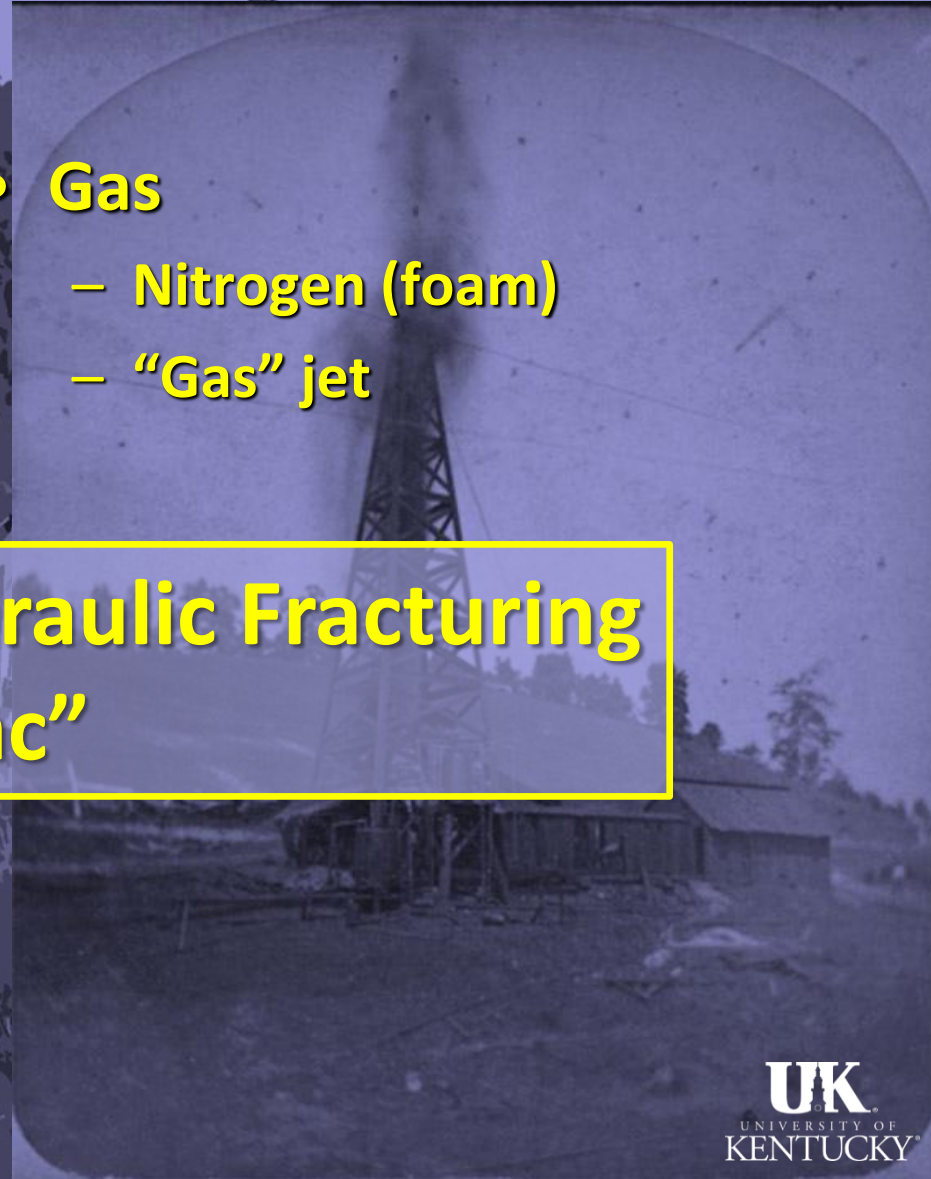
- Energized liquids

- Water
- Diesel
- Carbon dioxide
- Propane

- Gas

- Nitrogen (foam)
- “Gas” jet

Hydraulic Fracturing  
“Frac”





# Fracking in Practice

- Chemicals
  - Control fluid properties
  - Maintain well integrity
- Sand added to prop the new fractures open
- Release pressure
  - Recover frac fluid
  - Produce gas and liquids



# Nitrogen Frac, Eastern KY



*Courtesy Brint Camp, NGAS*



A photograph of a drilling rig operating in a wooded area. The rig is a tall, vertical structure with a flag on top, mounted on a trailer. A yellow excavator is positioned next to the rig. The background is filled with green trees and foliage.

# What chemicals are used?



# Industry Secrets

**INGREDIENTS:** ROLLED WHOLE GRAIN BLEND (OATS, HARD RED WHEAT, RYE, TRITICALE, BARLEY), DARK CHOCOLATE CHIPS (ORGANIC EVAPORATED CANE JUICE, CHOCOLATE LIQUOR, COCOA BUTTER, SOY LECITHIN, GROUND VANILLA BEANS), EXPELLER PRESSED CANOLA OIL, **KASHI** SEVEN WHOLE GRAIN FLOUR (WHOLE: OATS, HARD RED WHEAT, RYE, BROWN RICE, TRITICALE, BARLEY, BUCKWHEAT), HONEY, EVAPORATED CANE JUICE CRYSTALS, BROWN RICE SYRUP, CHICORY ROOT FIBER, OAT FIBER, VEGETABLE GLYCERIN, NATURAL FLAVORS, SODIUM BICARBONATE, SOY LECITHIN, SALT, MIXED TOCOPHEROLS FOR FRESHNESS, MONOCALCIUM PHOSPHATE, ALMONDS, EGGS, NONFAT DRY MILK, PEANUTS, WALNUTS.  
**CONTAINS WHEAT, SOY, ALMOND, EGG, MILK, PEANUT AND WALNUT INGREDIENTS. MAY CONTAIN OTHER TREE NUTS.**

**Kashi TLC Oatmeal Dark Chocolate Cookies**



# Public Disclosure:

# FracFocus.org

## What Chemicals Are Used

As previously noted, chemicals perform many functions in a hydraulic fracturing job. Although there are dozens to hundreds of chemicals which could be used as additives, there are a limited number which are routinely used in hydraulic fracturing. The following is a list of the chemicals used most often. This chart is sorted alphabetically by the Product Function.

for you to see the fracturing fluids.

Chemical Name	CAS	Chemical Purpose
Hydrochloric Acid	107-10-0	Helps dissolve minerals and create cracks in the rock

Glutaraldehyde	000111-30-8	Eliminates bacteria in the water that produces corrosive by-products
----------------	-------------	--

Quaternary Ammonium Chloride	012125-02-9	Eliminates bacteria in the water that produces corrosive by-products
------------------------------	-------------	--

Quaternary Ammonium Chloride	061789-71-0	Eliminates bacteria in the water that produces corrosive by-products
------------------------------	-------------	--

Tetrahydrodimethylphosphonium Sulfate	5566-00-8	Eliminates bacteria in the water that produces corrosive by-products
---------------------------------------	-----------	--

Ammonium Persulfate	007727-54-0	Allows a delayed break down of the gel
---------------------	-------------	--

Sodium Chloride	007647-14-5	Product Stabilizer
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Magnesium Peroxide	014452-57-4	Allows a delayed break down the gel
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Magnesium Oxide	001309-48-4	Allows a delayed break down the gel
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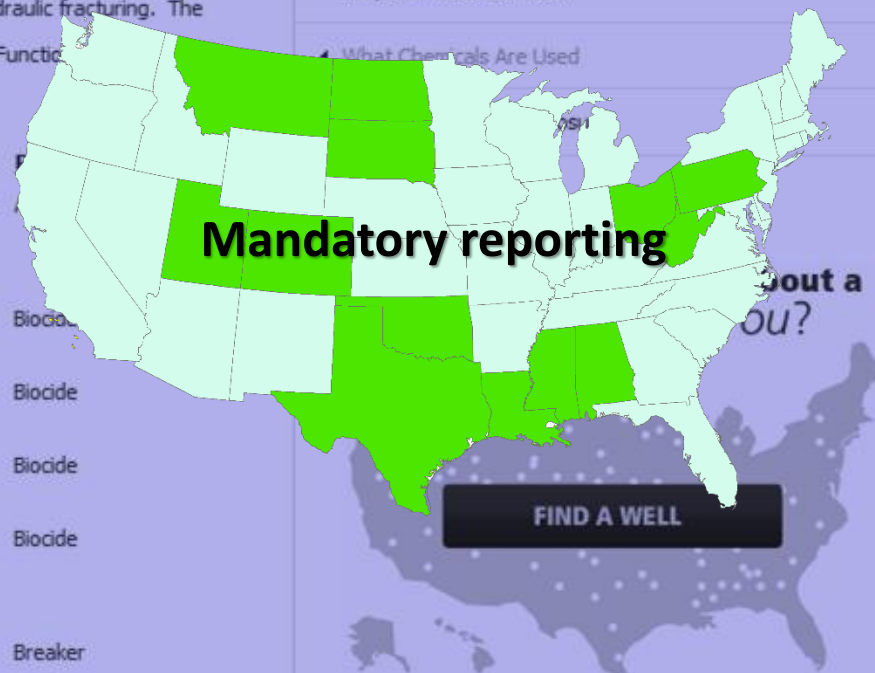
Calcium Chloride	010043-52-4	Product Stabilizer
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## Chemical Use in Hydraulic Fracturing

Introduction to Chemical Use

### Why Chemicals Are Used

### What Chemicals Are Used



Search for nearby well sites that have been hydraulically fractured to see what chemicals were used in the process.

[fracfocus.org/chemical-use/what-chemicals-are-used](http://fracfocus.org/chemical-use/what-chemicals-are-used)

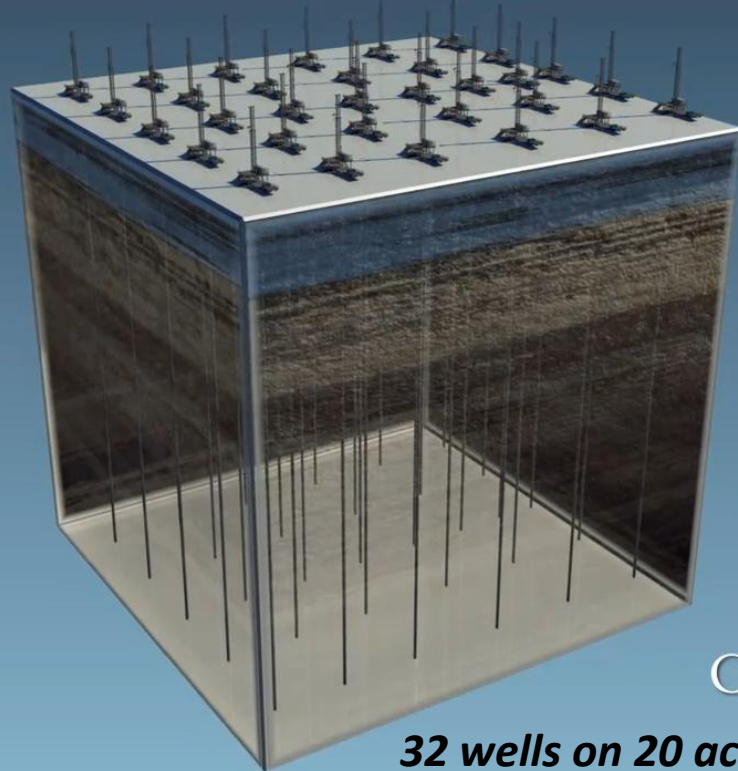


# Why horizontal wells?

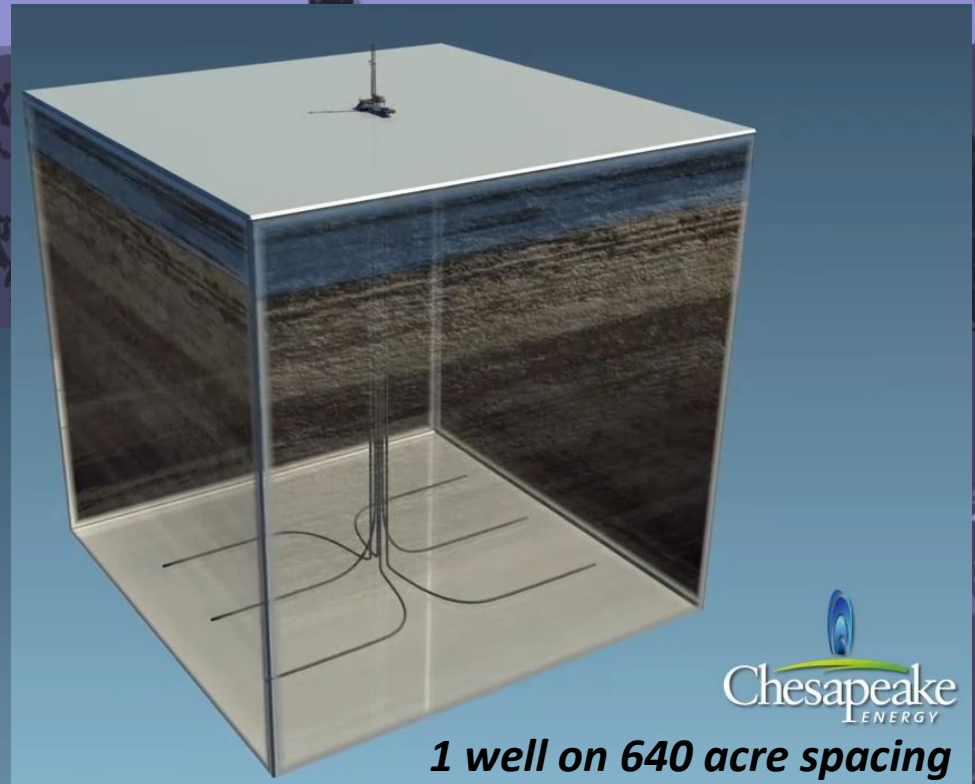


# Horizontal wells minimize surface impact of drilling.

Many surface locations



**32 wells on 20 acre spacing**



**1 well on 640 acre spacing**

Many underground laterals

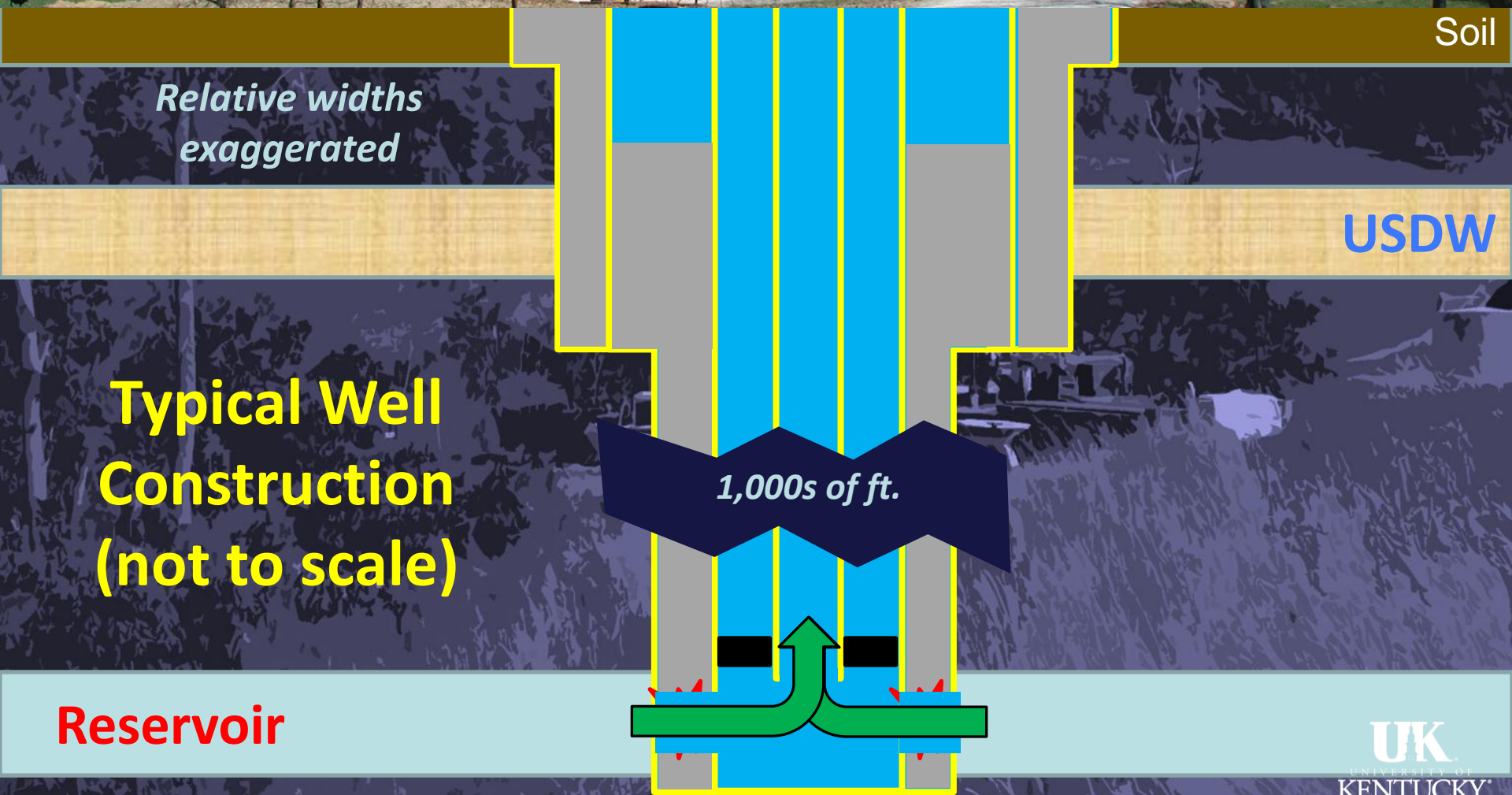


A photograph of a drilling rig in a wooded area. The rig is a tall, vertical structure with a flag on top, mounted on a trailer. It is surrounded by trees and foliage. A yellow excavator is visible in the foreground, and a white pickup truck is parked nearby. The scene is set in a natural, wooded environment.

# How is water protected?



A well is constructed using nested pipe, "casing", that is cemented into place.



Reservoir



# Spill Prevention Control and Counter Measures (SPCC)

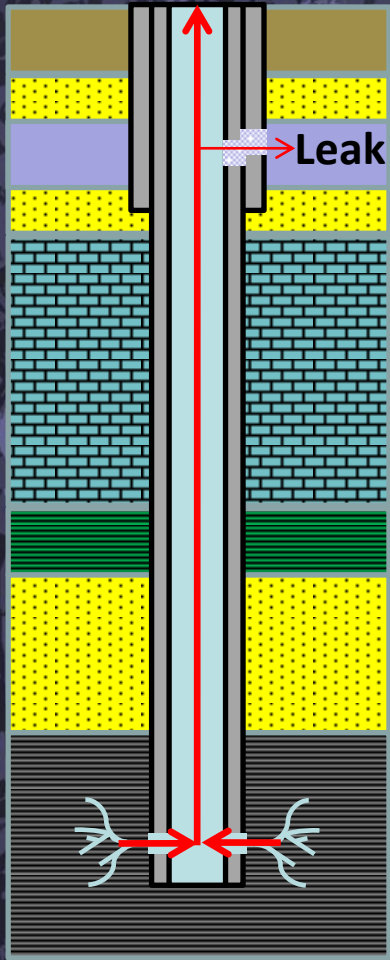


[www.epa.gov/osweroe1/content/spcc/index.htm](http://www.epa.gov/osweroe1/content/spcc/index.htm)





# Things can go wrong.



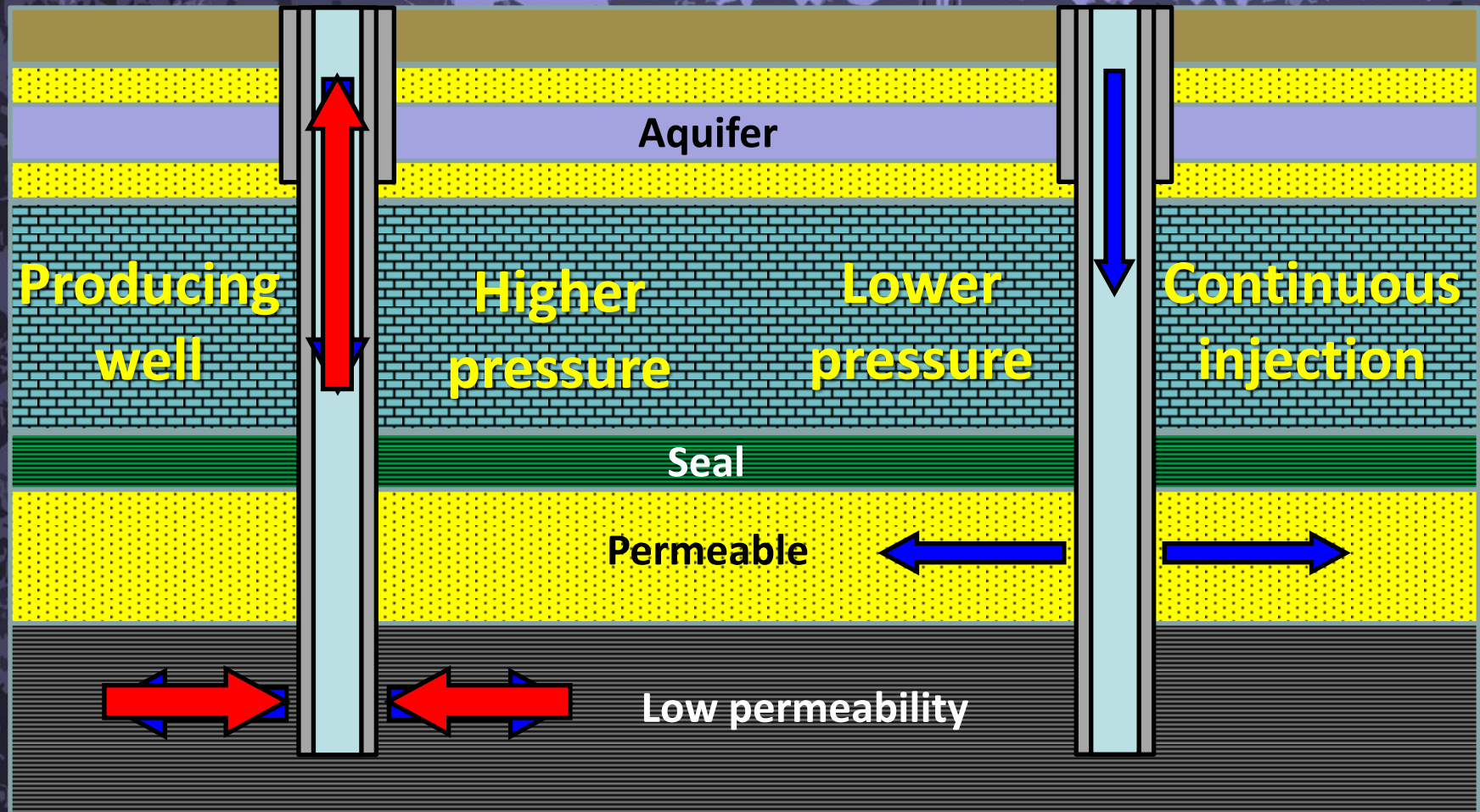
- **Water contamination**
  - Bad well construction (casing & cement)
    - Including domestic water supply wells
  - Surface spills
  - Frac out of zone
    - Encounter an unexpected fracture or old well bore
    - Kentucky plugging fund
- **Induced seismicity**



# Differences in Fluid Management

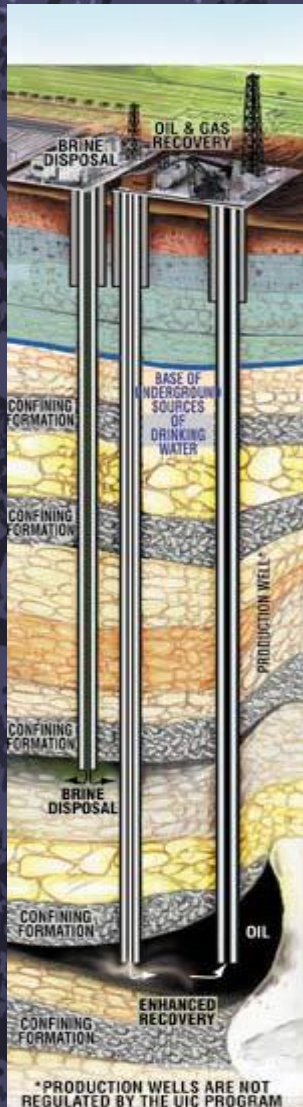
Fracking

Disposal





# Earthquakes & underground injection (USGS and NRC findings)



- “Felt” earthquakes
  - Wastewater disposal
  - Injection wells
- Waste injection is safe and regulated to protect fresh water
  - Many thousands of disposal wells
  - Few dozens with potential problems

U.S. EPA UIC Class II  
[water.epa.gov/type/groundwater/uic/class2/index.cfm](http://water.epa.gov/type/groundwater/uic/class2/index.cfm)



# Earthquakes and Fracking

A background photograph of a fracking site. In the center, a tall, vertical drilling rig stands prominently. To its left, a yellow excavator is visible. The site is surrounded by dense green trees and foliage. The ground appears to be a mix of dirt and grass.

- Durham Energy Institute
- Causes of induced seismicity
  - Research
  - Salt solution mining
  - Waste disposal
  - Geothermal
  - Oil/gas field depletion
  - Mining
  - Reservoir impoundment
  - Shale gas fracking
- Collected published examples



# Fracking Study Conclusions

- Can reactivate faults
  - Well known
  - Readily detected
- Likely to induce felt events in future
- Not an important mechanism for causing felt earthquakes



# What to do about earthquakes?

- **Improve site characterization & permitting**
  - 3D reflection seismic to find faults & fractures
- **Improve monitoring**
  - Surface & bottom hole pressures & rates
  - Injection & surrounding wells
- **Improve operational guidelines & BMP**

With careful design and monitoring,  
risks can be minimized or avoided.

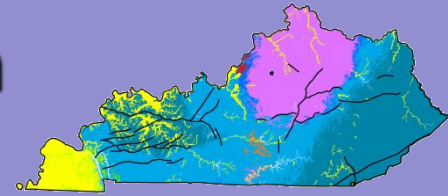


The background image shows a large industrial drilling rig with a tall vertical mast and a flag on top, situated on a grassy hillside. A large yellow excavator is positioned in front of the rig. The scene is surrounded by trees and foliage, suggesting a rural or undeveloped area.

# What is happening in Kentucky?



# Fracture stimulation has been used in Kentucky for more than 200 years

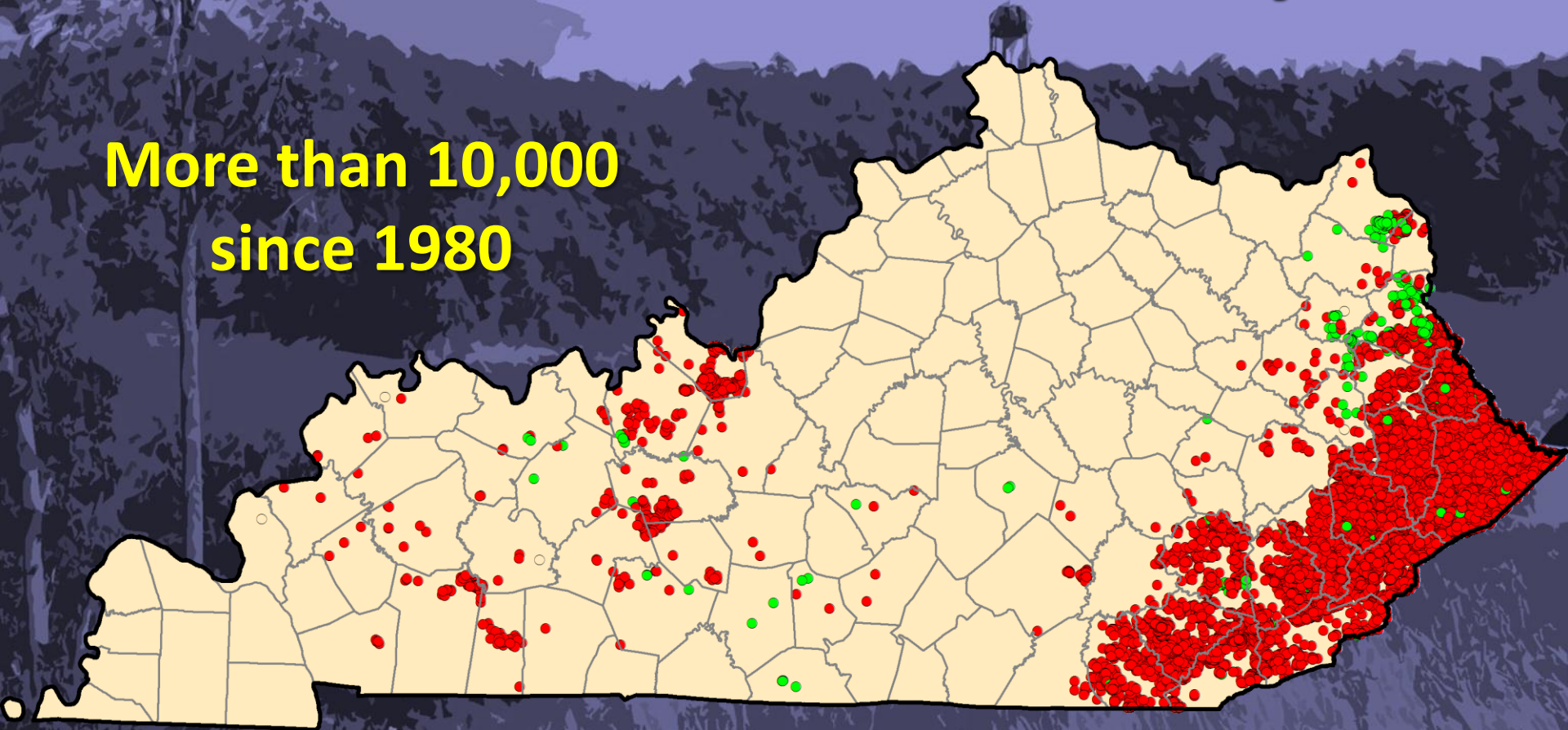


- Before 1806: Explosives improve water wells
- 1888: 1<sup>st</sup> Kentucky oil well to be “shot”
- 1960: Hydraulic fracturing
  - 1946: 1<sup>st</sup> in U.S. (Kansas)
- 1972: Shale – nitrogen frac
- 2007: Horizontal wells – foam frac
- 2010: Hydraulic fracks
  - Berea (Lawrence and Greenup Counties)
  - New Albany shale (Breckinridge County)



# Fracked Wells in Kentucky

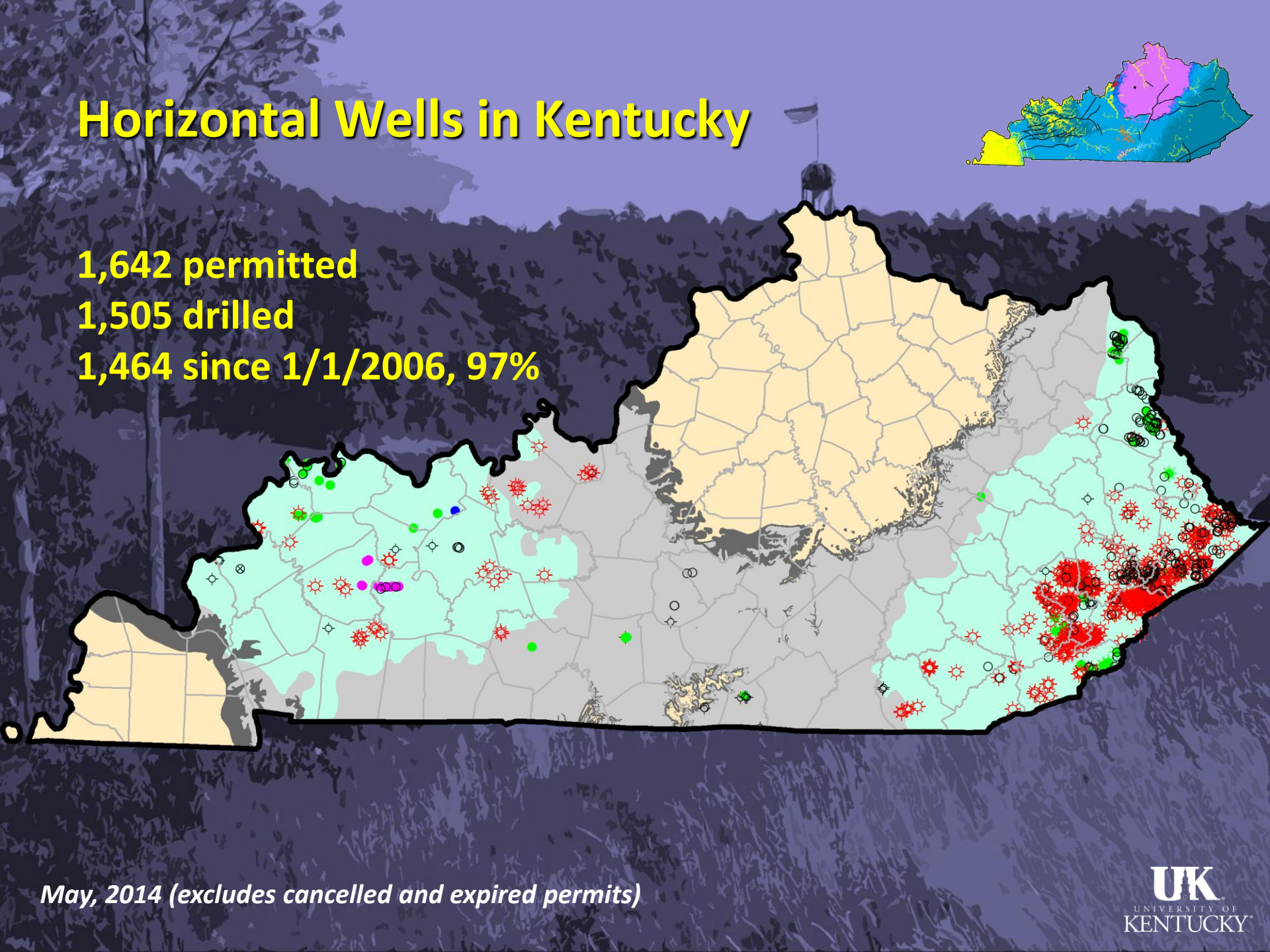
More than 10,000  
since 1980





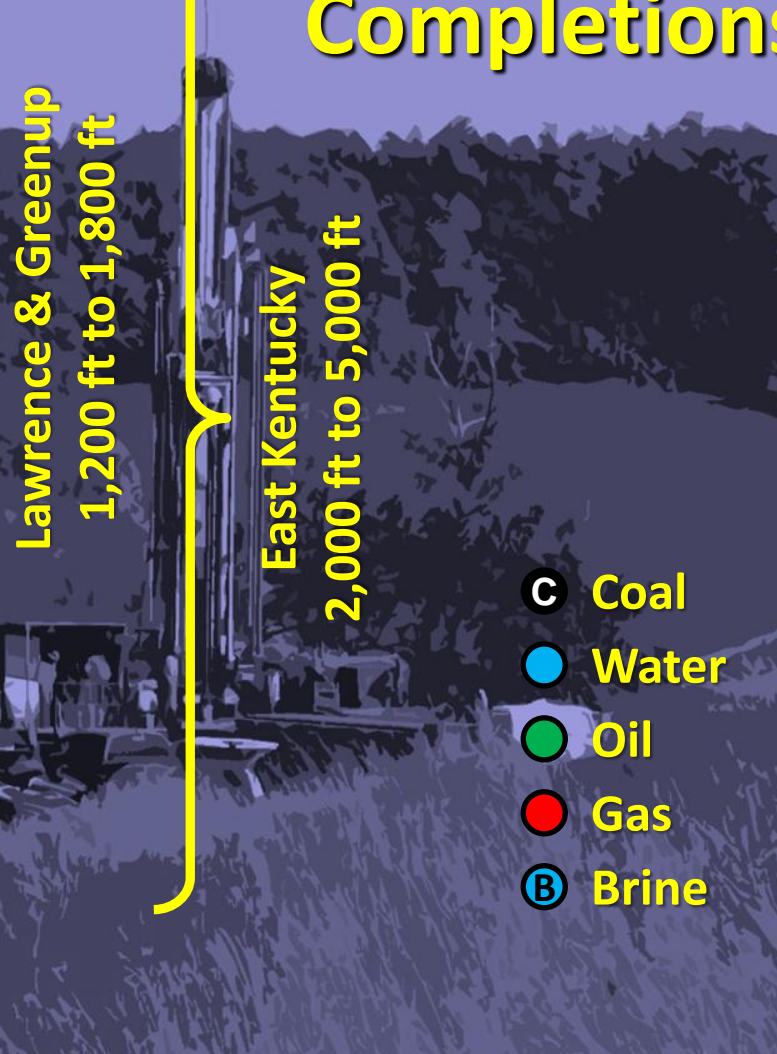
# Horizontal Wells in Kentucky

1,642 permitted  
1,505 drilled  
1,464 since 1/1/2006, 97%



*May, 2014 (excludes cancelled and expired permits)*





# Typical Completions

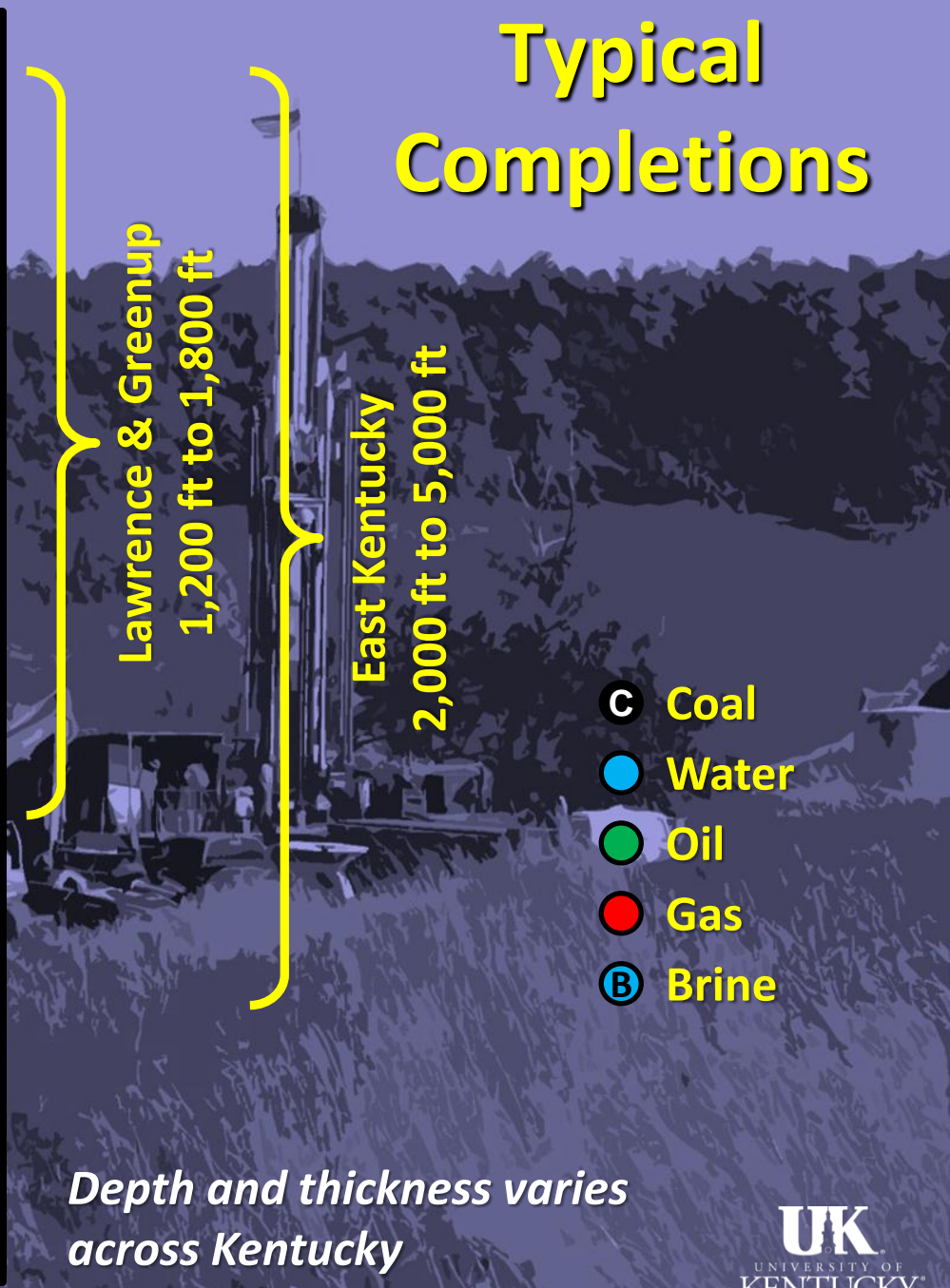
Lawrence & Greenup  
1,200 ft to 1,800 ft

East Kentucky  
2,000 ft to 5,000 ft

- Coal
- Water
- Oil
- Gas
- Brine

*Depth and thickness varies across Kentucky*

**UK**  
UNIVERSITY OF KENTUCKY



# Typical Completions

Lawrence & Greenup  
1,200 ft to 1,800 ft

East Kentucky  
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- C Coal
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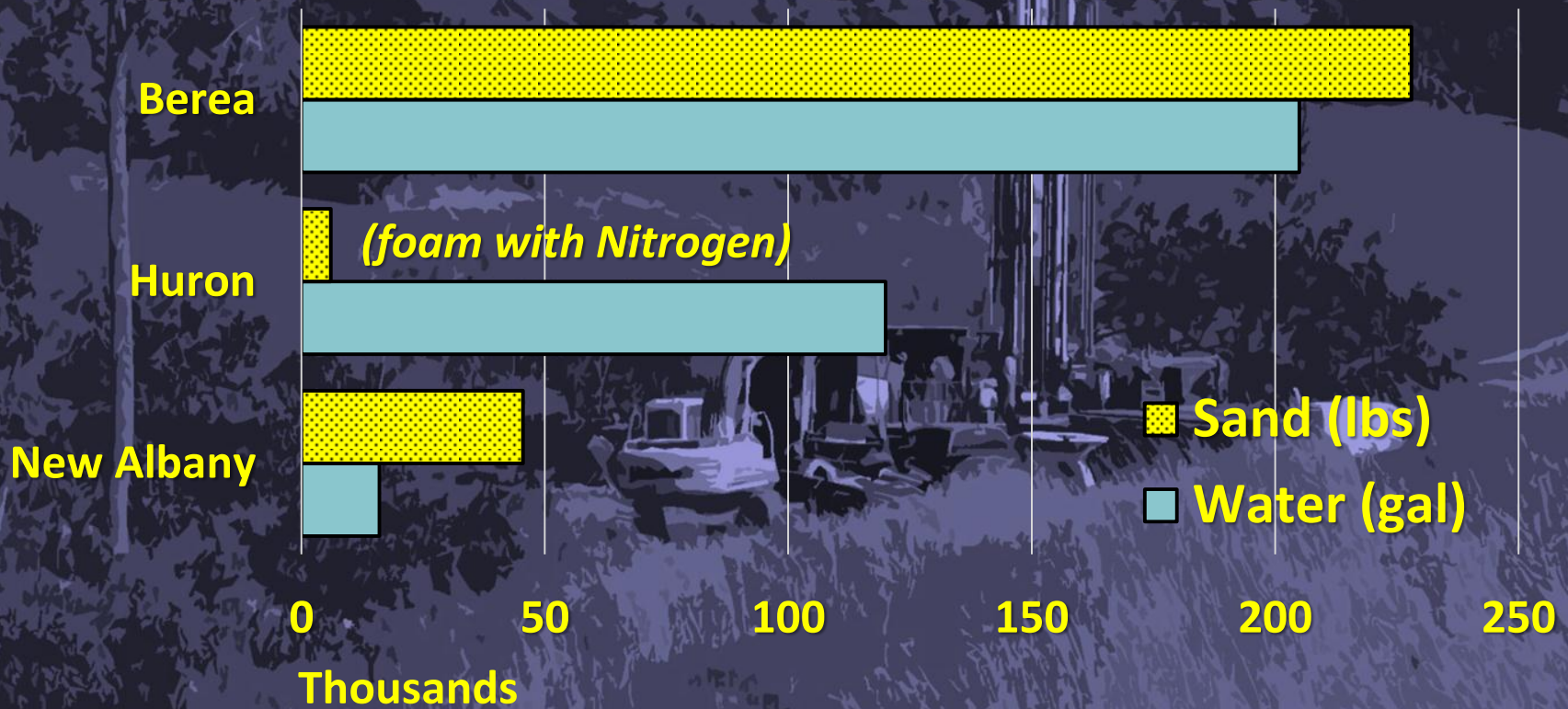
*Depth and thickness varies across Kentucky*

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# Water Use in Kentucky Fracks

Chart Title





# Kentucky Natural Gas Production

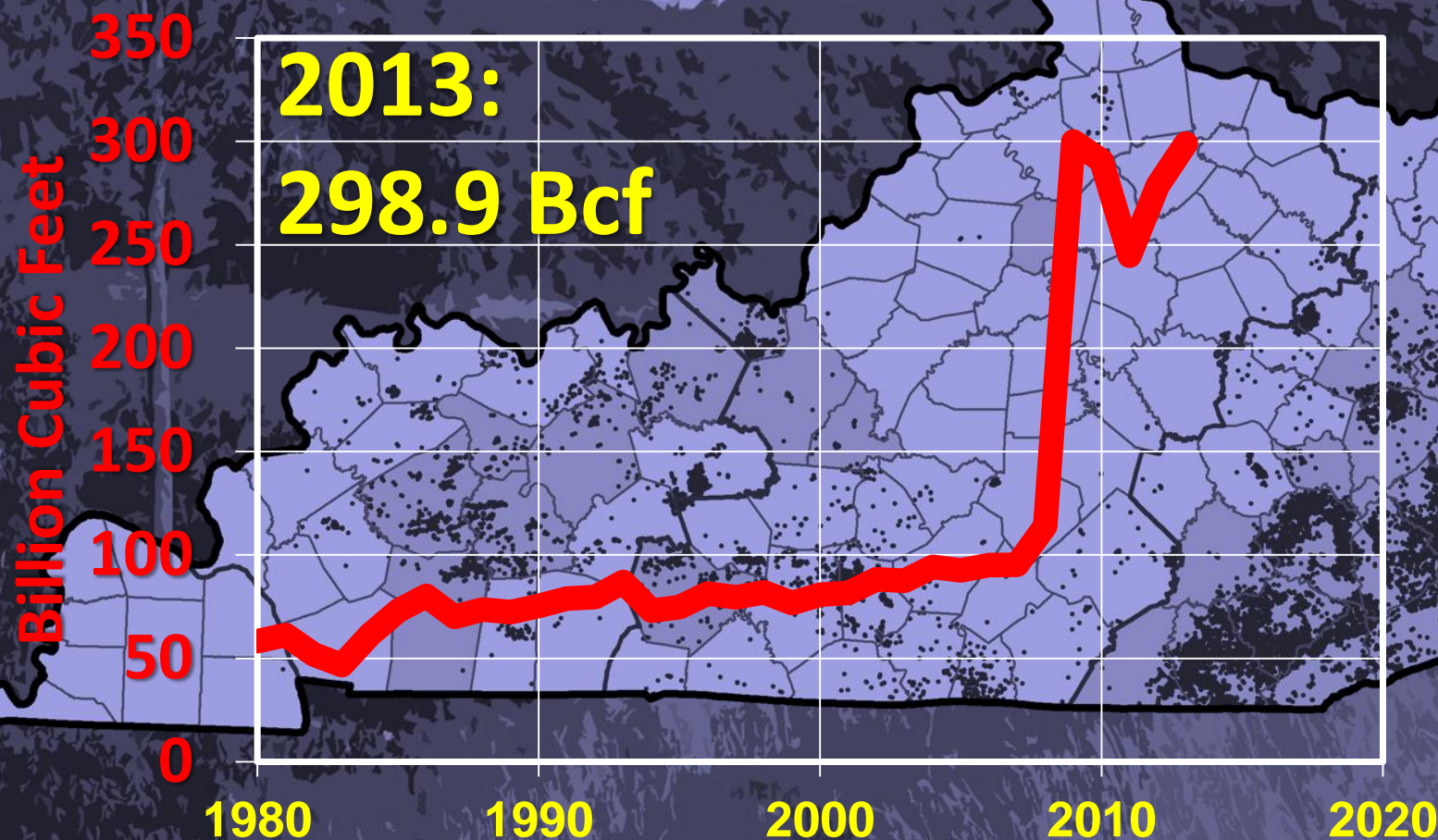
**2013:  
298.9 Bcf**

**99.6%**

**34 Kentucky counties**



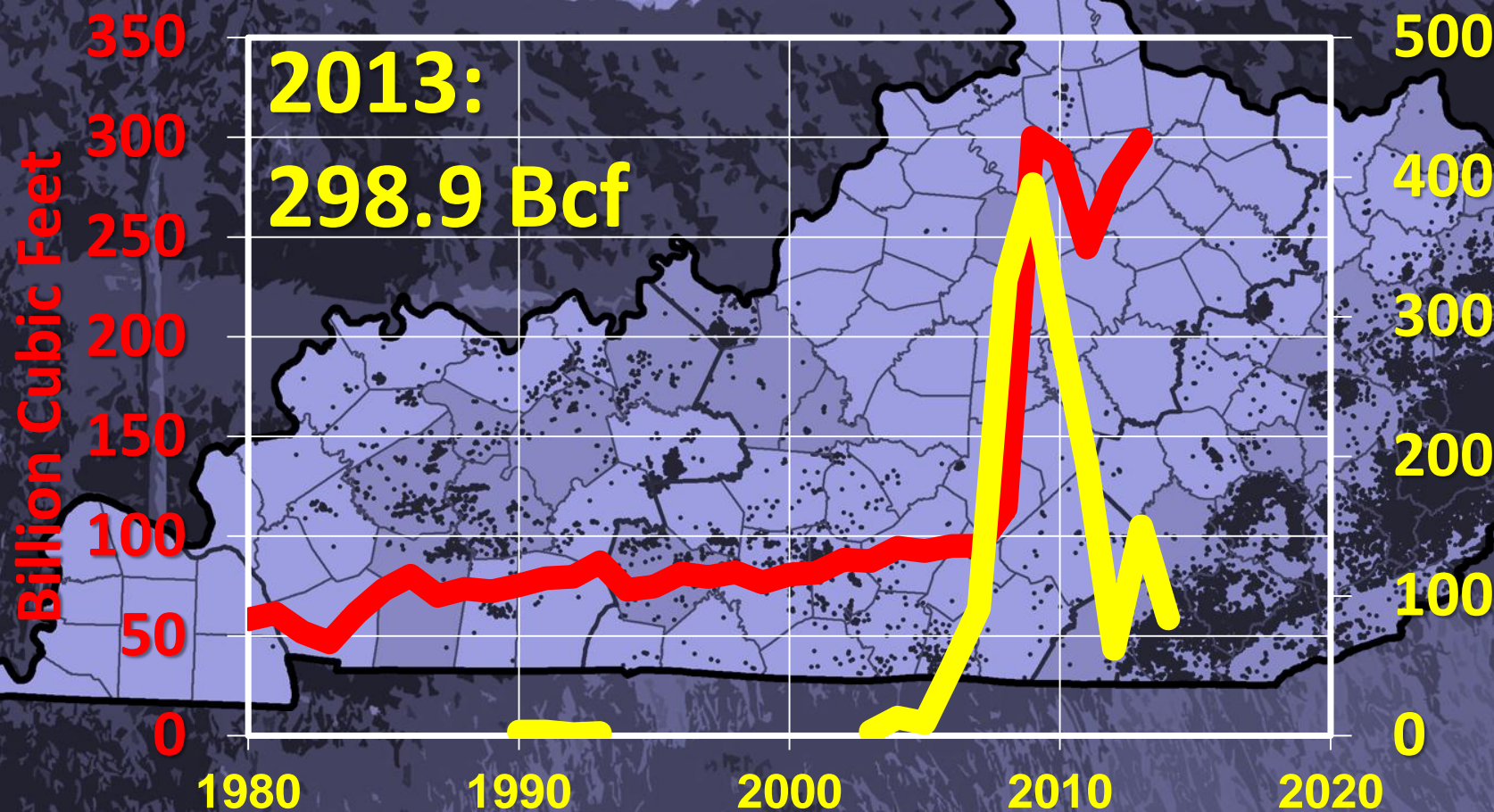
# Kentucky Natural Gas Production



34 Kentucky counties



# Kentucky Natural Gas Production

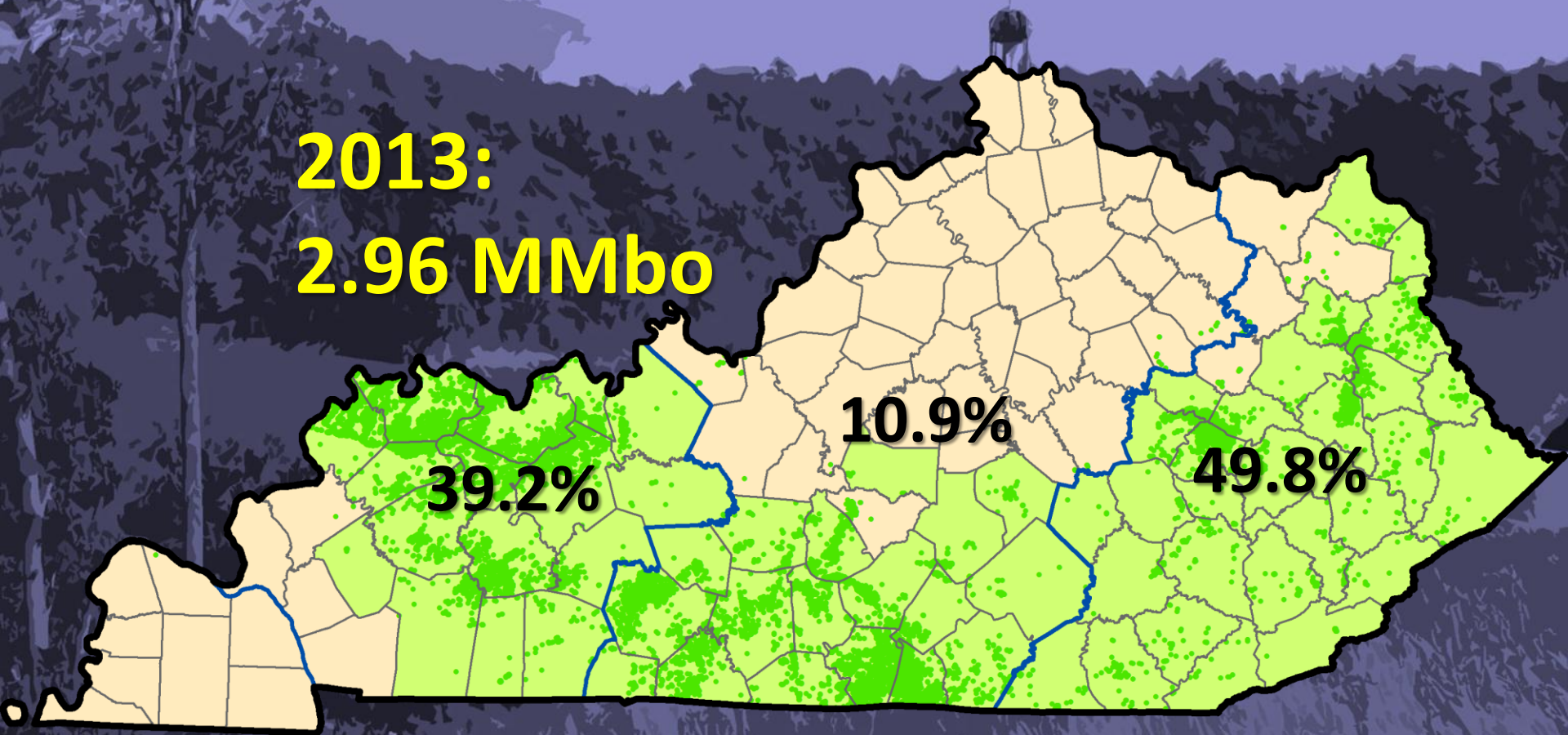


34 Kentucky counties



# Kentucky Oil Production

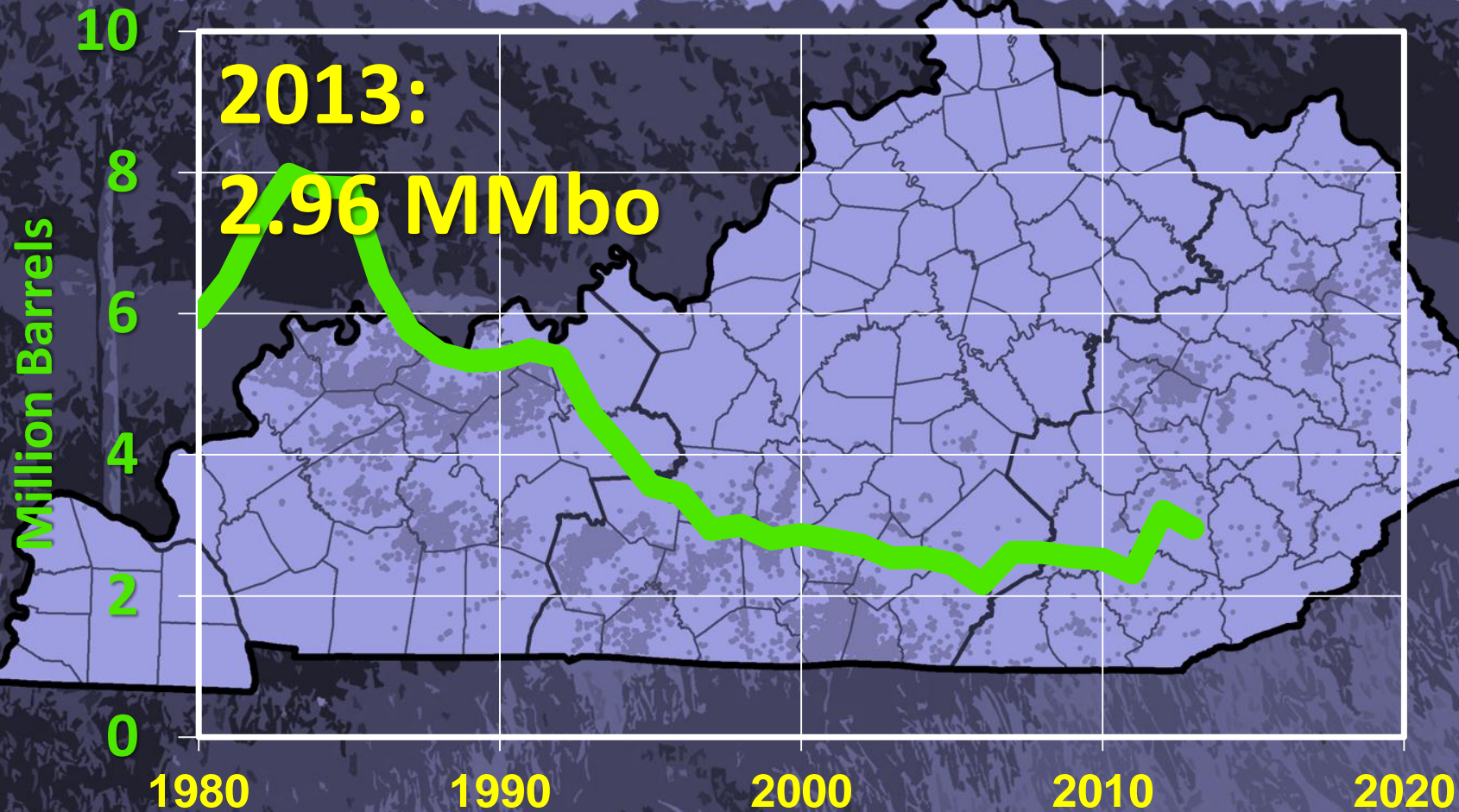
**2013:  
2.96 MMbo**



63 Kentucky counties



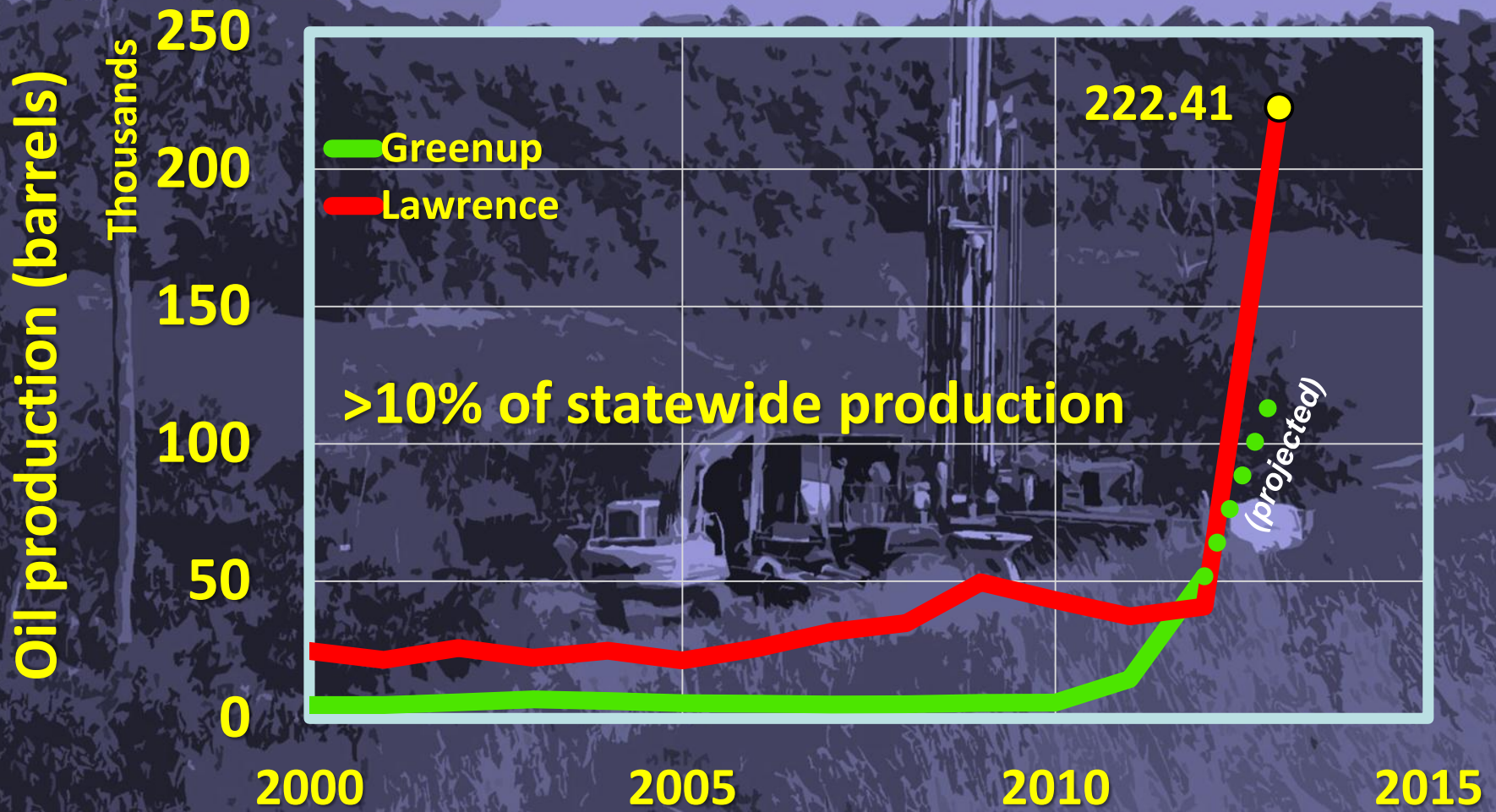
# Kentucky Oil Production



63 Kentucky counties



# Berea Oil Production, East Kentucky



2013 production volume for Greenup County is confidential (3 or fewer respondents)



# Horizontal Wells since 2006

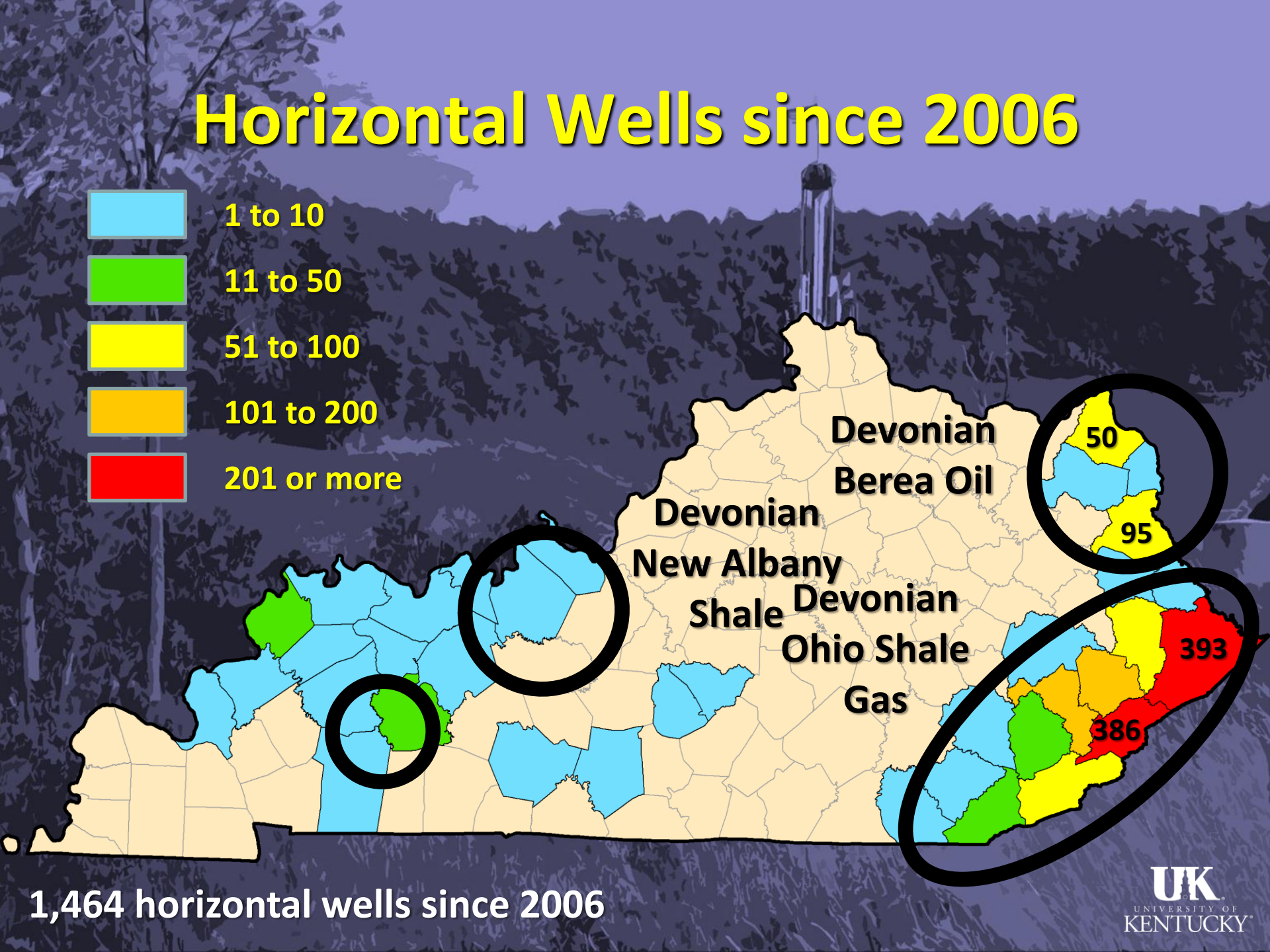
1 to 10  
11 to 50  
51 to 100  
101 to 200  
201 or more

Devonian  
Berea Oil  
Devonian  
New Albany  
Shale  
Devonian  
Ohio Shale  
Gas

50  
95  
393  
386

1,464 horizontal wells since 2006

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KENTUCKY



# Horizontal Wells since 2006

1 to 10

11 to 50

51 to 100

101 to 200

201 or more

Devonian Berea Oil

Devonian New Albany Shale

Devonian Ohio Shale Gas

50

95

393

386

1,464 horizontal wells since 2006

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KENTUCKY



The background image shows a construction site on a grassy hillside. A large, tall drilling rig with a flag on top is the central focus. To its left, there are several excavators and other construction equipment. The hillside is covered in green grass and some trees are visible in the background under a clear blue sky.

**How do you verify it's being  
done properly?**





# Energy and Environment Cabinet

## Department for Natural Resources

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Division of Oil and Gas

[eec.ky.gov](#)

Search



[oilandgas.ky.gov](http://oilandgas.ky.gov)

### Division of Oil and Gas

The mission of the Division of Oil and Gas is to regulate the crude oil and natural gas industry in the Commonwealth; protect the correlative rights of mineral owners, fresh water zones and minable coal seams; and conserve and protect oil and gas reserves in Kentucky.

The Division of Oil and Gas maintains a well history database for each well containing data relative to the permit, operator, well location, pertinent dates and well completion. Currently, there are 136,286 wells stored online. This information is shared with the Kentucky Geological Survey (KGS) to assist in the compilation of oil and gas data.



### Quick Links

[Kentucky Geological Survey](#)



# Public records: [www.uky.edu/kgs](http://www.uky.edu/kgs)



Online search

Interactive maps

Enable pop up windows!



KGS home page



Scanned documents are available for  
browsing, printing, or downloading.

Public records

Completion and stimulation

COMMONWEALTH OF KENTUCKY  
DEPARTMENT FOR NATURAL RESOURCES  
DIVISION OF OIL AND GAS CONSERVATION  
P.O. Box 2244  
FRANKFORT, KY 40601 PHONE (502) 573-0147



Kentucky Geological Survey



F WELL LOG  
TION REPORT  
D BY LAW

(TYPE OR PRINT IN INK)

OPERATOR'S PHONE: 606-785-0761

WELL IDENTIFICATION PERMIT NO. 104874

OPERATOR Clean Gas, Inc.

FARM NAME Emory Moore Heirs WELL NO. 375

LOCATION Letcher

TYPE OF OPERATION

TWIN ☐

REOPEN ☐

NEW WELL ☒

WORKOVER ☐

DEEPENING ☐

SEC. 20 LTR H NO. 80

2840 ☐ FNL 1537 ☐ FEL

ELEVATION 1418 (GROUND) (D.F.)

OPERATIONAL DATES

COMMENCED 12/16/2009 COMPLETED 01/12/2010

PLACED IN OPERATION

PLUGGED SHUT-IN 01/15/2010

DILLING CONTRACTOR

NAME Crudewell Drilling, Inc.

ADDRESS P.O. Box 10

Albany, KY 42002

WATER ENCOUNTERED

TYPE FRESH WATER

SALT WATER

None

None

None

None

None

None

None

None

None

None

None

None

None

None

None

None

None

None

None

None

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None

None

None

WELL TREATMENT TYPE OF FRAC.

TYPE SHOT Select Fire & HSC

SHOT INTERVAL Shale(1) = 4197-4361 Shale(2) = 3873-4064

SHOT AMOUNT Big Lime(3) = 3420-3448

COMPLETION INTERVAL, PERFORATIONS OR OPEN HOLE

FORMATION Shale(1) INTERVAL 4197-4361 20H

FORMATION Shale(2) INTERVAL 3873-4064 20H

PLUGGED Big Lime (3) SHUT-IN 3420-3448 22H

TREATMENT

TYPE OF TREATMENT Shale(1) &(2) = N2 Big Lime = 65Q Foamed Acid

ACID AMOUNT (1)=12,(2)=6 BBLs (3)=95.3 BBLs

TOTAL FLUID (1)=12,(2)=6 BBLs (3)=95.3 BBLs

TOTAL NITROGEN (1)=901,400 (2)=901,100 (3)=271,000 SCF

TOTAL SAND \_\_\_\_\_ LBS

CASING DATA					
CASING OUTSIDE DIAMETER	HOLE DIAMETER	DEPTH	CEMENT NO. SKS	PULLED YES/NO	
13 3/8"	17 1/2"	58	0	NO	
9 5/8"	12 1/4"	494	185	NO	
4 1/2"	8 7/8"	4435	310	NO	

CEMENT YIELD IN CUBIC FEET/BACK = 368 CUBIC FEET/BACK

COMMENTS 9 5/8" = 185 sks (1.20 R3/sk)

4 1/2" = 310 sks (1.9 R3/sk)

WELL TREATMENT TYPE OF FRAC.

SHOT

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# Conclusion

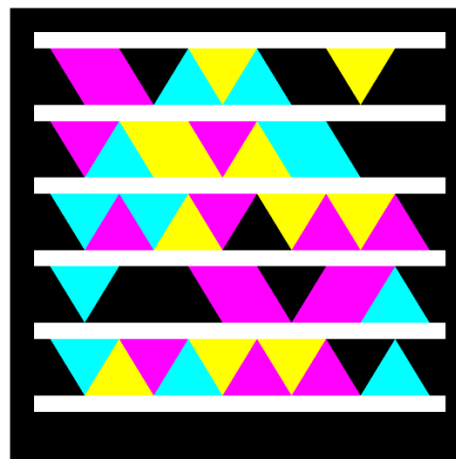
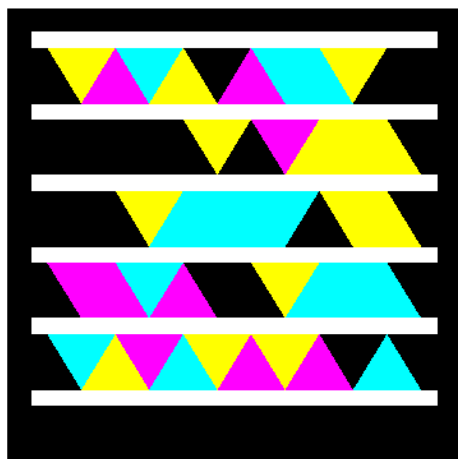
- Focus on well construction
  - Oil and gas wells
  - Domestic water supply
- SPCC
- Support
  - Disclosure – [FracFocus.org](http://FracFocus.org)
  - Enforcement
    - Division of Oil and Gas
    - Division of Water

Fracking is an effective technology for accessing natural resources



# Thank you

- [bnuttall@uky.edu](mailto:bnuttall@uky.edu)
- [www.uky.edu/KGS](http://www.uky.edu/KGS)
- (859) 323-0544





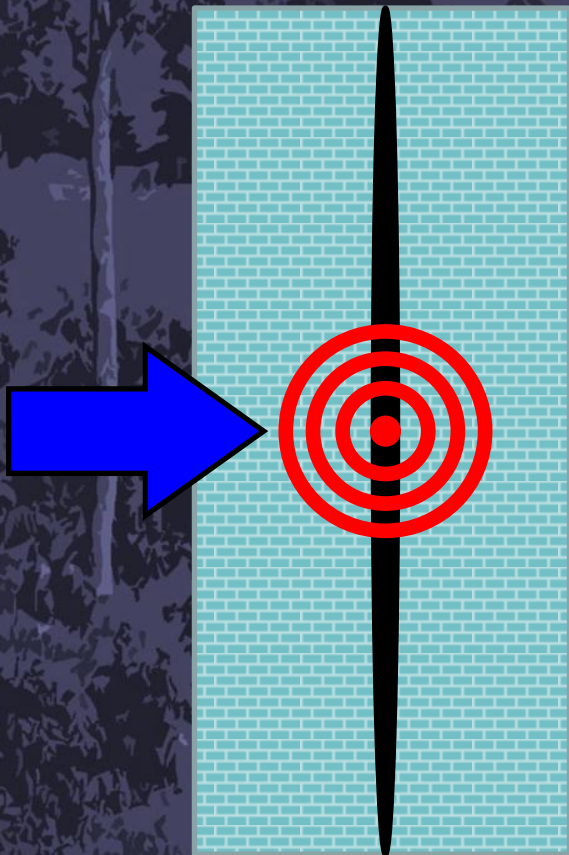
The background image shows a large industrial drilling rig with a tall vertical mast and a flag on top, situated in a wooded area. In the foreground, a large yellow excavator is visible, partially obscured by the text. The scene is set in a clearing with trees and a grassy area.

# Addendum on Induced Seismicity



# Mechanisms for Earthquakes

## Mechanical Strength





# Mechanisms for Earthquakes

Mechanical Strength

Friction

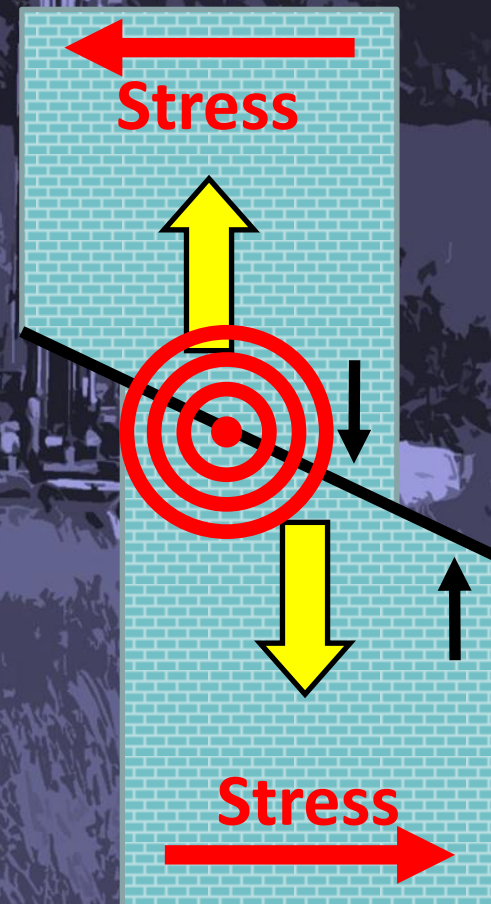
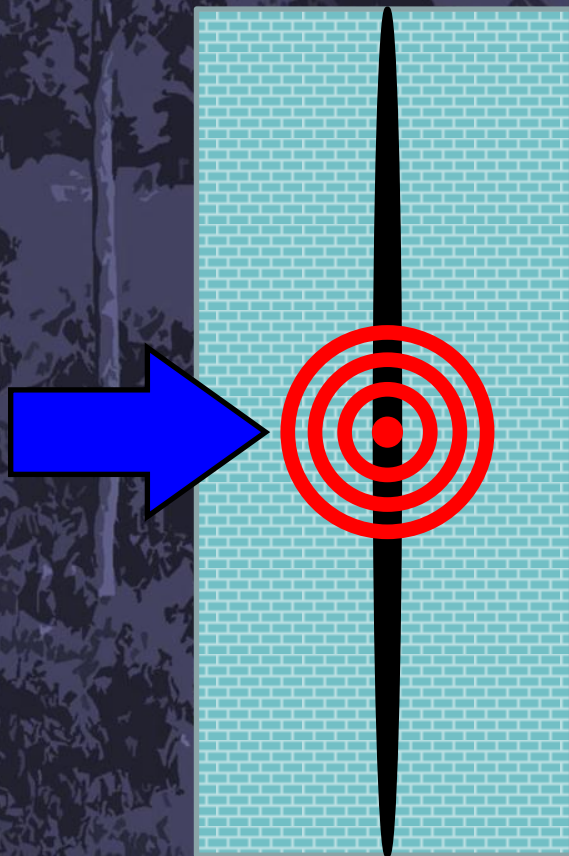




# Mechanisms for Earthquakes

Mechanical Strength

Friction





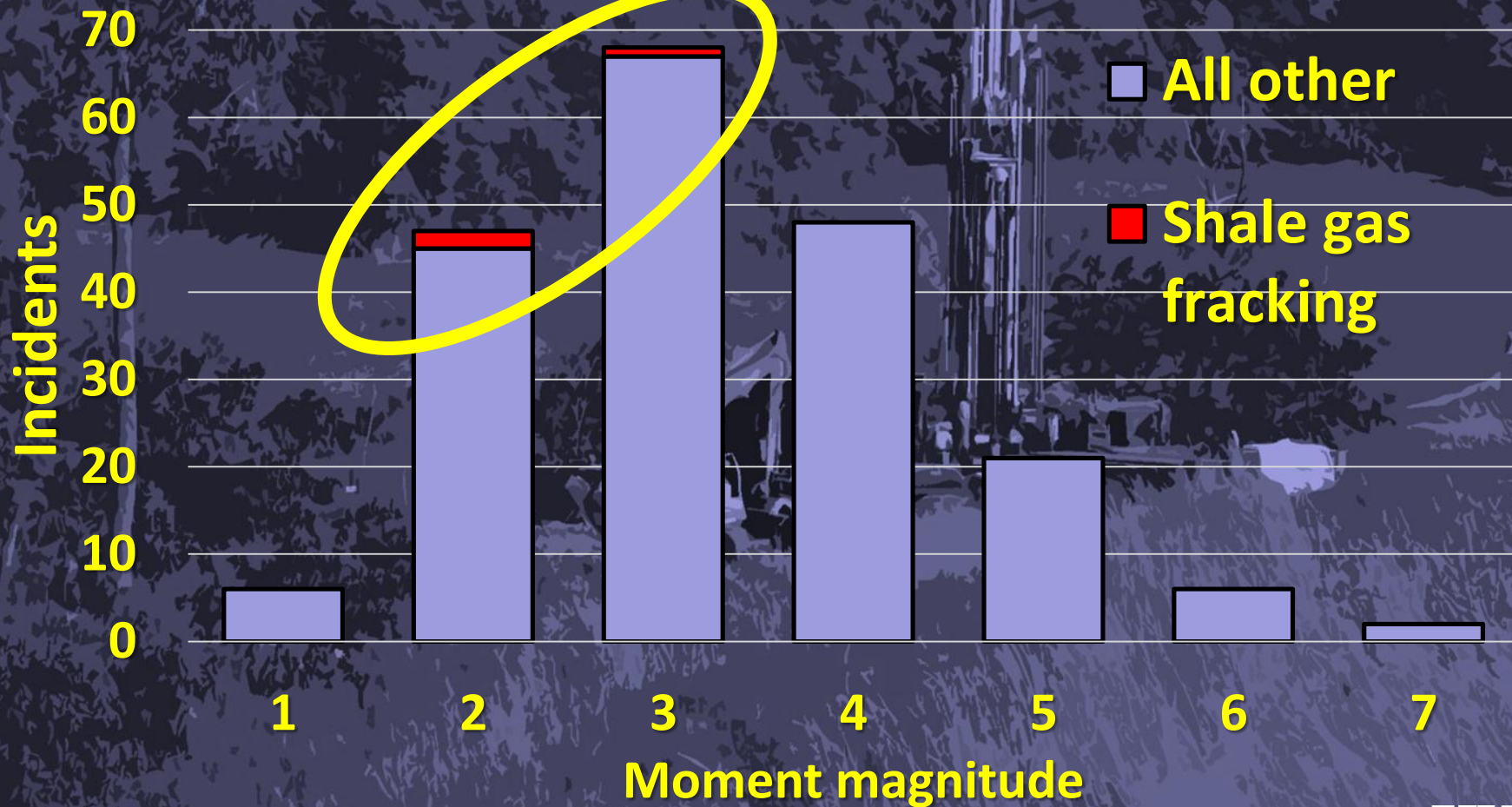
# Earthquakes and Fracking



- Durham Energy Institute
- Causes of induced seismicity
  - Research
  - Salt solution mining
  - Waste disposal
  - Geothermal
  - Oil/gas field depletion
  - Mining
  - Reservoir impoundment
  - Shale gas fracking
- Collected 198 published examples
  - >1 event at a location then used maximum magnitude



# Causes

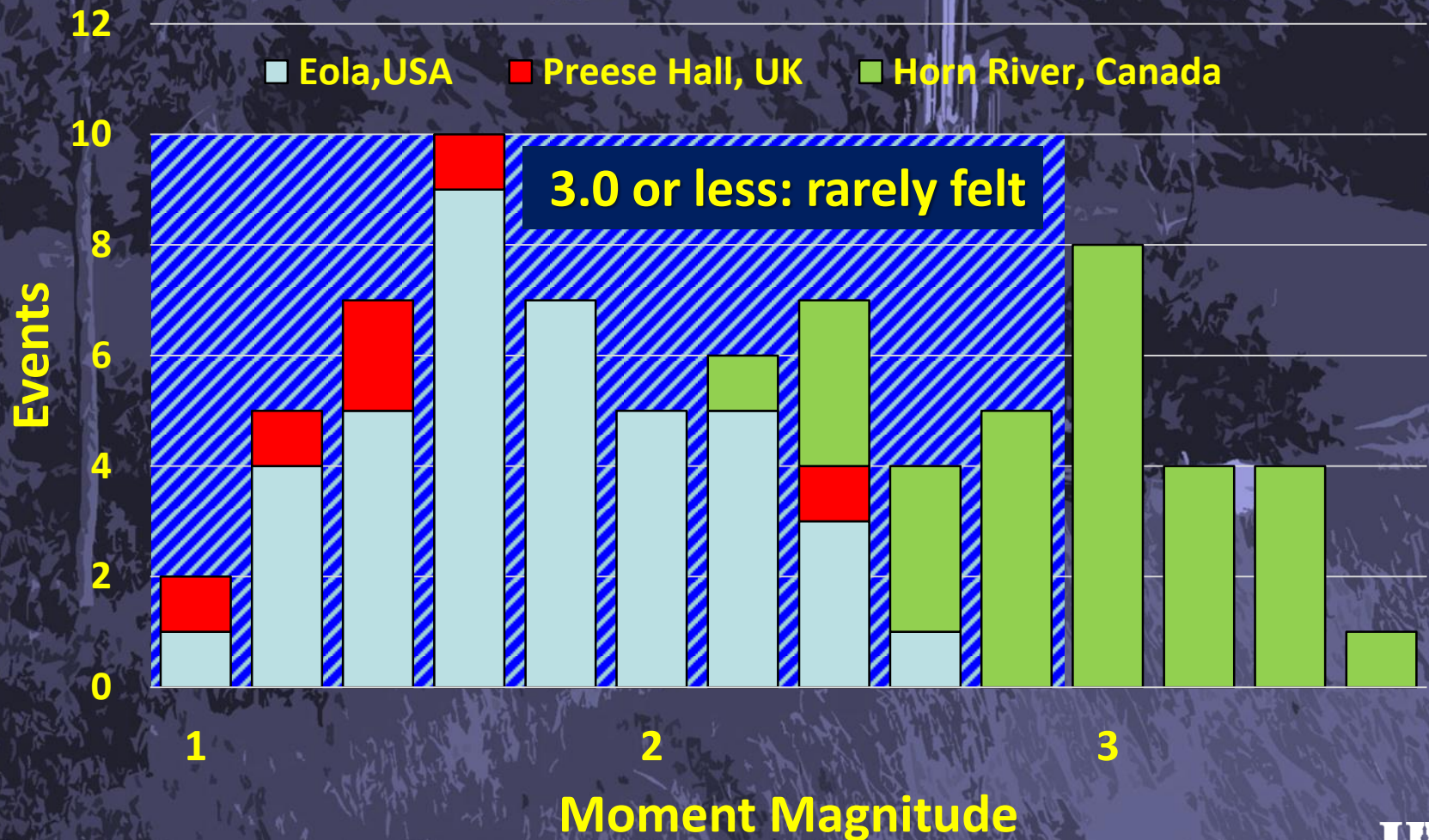








# Size of Earthquakes from Fracking



79 events, from Davis and others, Marine & Petroleum Geology, 2013, Fig 3.



# Fracking Study Conclusions

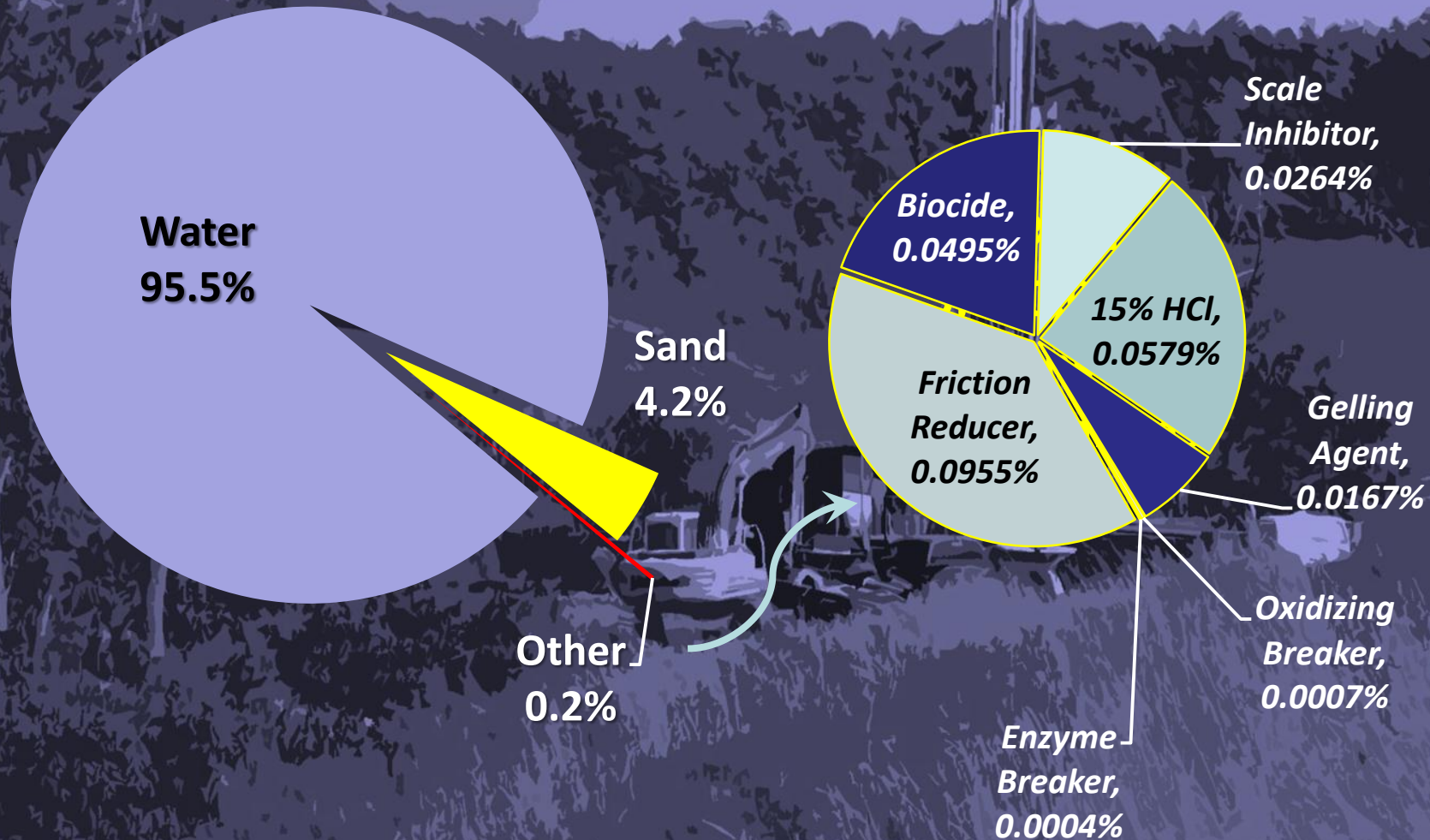
- Can reactivate faults
  - Well known
  - Readily detected
- Likely to induce felt events in future
- Not an important mechanism for causing felt earthquakes



# Addendum on Chemicals



# Hydraulic fracturing uses mostly water with some sand.



Back